Top Previous Next Index

LEVEL 61 RPI a-Si TFT Model

Star-Hspice LEVEL 61 is an AIM-SPICE MOS15 amorphous silicon (a-Si) thin-film transistor (TFT) model.

Model Features

AIM-SPICE MOS15 a-Si TFT model features include:

- Modified charge control model; induced charge trapped in localized states
- Above threshold includes:
  - Field effect mobility becoming a function of gate bias
  - Band mobility dominated by lattice scattering
- Below threshold
  - Fermi level located in deep localized states
  - Relate position of Fermi level, including the deep DOS back to the gate bias
- Empirical expression for current at large negative gate biases for hole-induced leakage current
- Interpolation techniques are applied to the equations to unify the model

Using LEVEL 61 with Star-Hspice

When using the AIM-SPICE MOS15 a-Si TFT model:

1. Set LEVEL=61 to identify the model as the AIM-SPCIE MOS15 a-Si TFT model.

2. The default value for L is 100m, and the default value for W is 100m.

3. The LEVEL 61 model is a 3-terminal model. No bulk node exists; therefore no parasitic drain-bulk or source-build diodes are appended to the model. A fourth node can be specified, but does not affect simulation results.

4. The default room temperature is 25C in Star-Hspice, but is 27C in some other simulators. The user may choose whether or not to set the nominal simulation temperature to 27C, by adding .OPTION TNOM=27 to the netlist.

Example

This is an example of how the Star-Hspice model and element statement modified for use with LEVEL 61.

mckt drain gate source nch L=10e-6 W=10e-6

.MODEL nch nmos LEVEL=61

+ alphasat = 0.6 cgdo = 0.0 cgso = 0.0 def0 = 0.6

+ delta = 5.0 el = 0.35 emu = 0.06 eps = 11

+ epsi = 7.4 gamma = 0.4 gmin = 1e23 iol = 3e-14

+ kasat = 0.006 kvt = -0.036 lambda = 0.0008 m = 2.5

+ muband = 0.001 rd = 0.0 rs = 0.0 sima0 = 1e-14

+ tnom = 27 tox = 1.0e-7 v0 = 0.12 vaa = 7.5e3

+ vdsl = 7 vfb = -3 vgsl = 7 vmin = 0.3 vto = 0.0

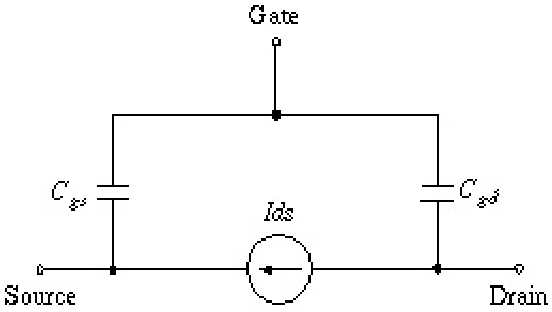
LEVEL 61 Model Parameters

Name	Unit	Default	Description
ALPHASAT	-	0.6	Saturation modulation parameter
CGDO	F/m	0.0	Gate-drain overlap capacitance per meter channel width
CGSO	F/m	0.0	Gate-source overlap capacitance per meter channel width
DEF0	eV	0.6	Dark Fermi level position
DELTA	-	5	Transition width parameter
EL	eV	0.35	Activation energy of the hole leakage current
EMU	eV	0.06	Field effect mobility activation energy
EPS	-	11	Relative dielectric constant of substrate
EPSI	-	7.4	Relative dielectric constant of gate insulator
GAMMA	-	0.4	Power law mobility parameter
GMIN		1E23	Minimum density of deep states

	m-3eV-1		
IOL	A	3E-14	Zero bias leakage current parameter
KASAT	1/° C	0.006	Temperature coefficient of ALPHASAT
KVT	V/° C	-0.036	Threshold voltage temperature coefficient
LAMBDA	1/V	0.0008	Output conductance parameter
M	-	2.5	Knee shape parameter
MUBAND	m2/Vs	0.001	Conduction band mobility
RD	µ	0.0	Drain resistance
RS	µ	0.0	Source resistance
SIGMA0	A	1E-14	Minimum leakage current parameter
TNOM	oC	25	Parameter measurement temperature
TOX	m	1E-7	Thin-oxide thickness
V0	V	0.12	Characteristic voltage for deep states
VAA	V	7.5E3	Characteristic voltage for field effect mobility
VDSL	V	7	Hole leakage current drain voltage parameter
VFB	V	-3	Flat band voltage
VGSL	V	7	Hole leakage current gate voltage parameter

VMIN	V	0.3	Convergence parameter
VTO	V	0.0	Zero-bias threshold voltage

Equivalent Circuit



Model Equations

Drain Current

$$I_{ds} = I_{leakage} + I_{ab}$$

$$I_{ab} = g_{ch} V_{dse} (1 + LAMBDA \cdot V_{ds})$$

$$V_{dse} = \frac{V_{ds}}{[1 + (V_{ds} / V_{sate})^{M}]^{1/M}}$$

$$V_{sate} = \alpha_{sat} V_{gte}$$

$$g_{ch} = \frac{g_{chi}}{1 + g_{chi}(RS + RD)}$$

$$g_{chi} = q n_{s} W \cdot MUBAND / L$$

$$n_s = \frac{n_{sa} n_{sb}}{n_{sa} + n_{sb}}$$

$$n_{sb} = n_{so}\left(\frac{t_m}{\mathrm{TOX}}\frac{V_{gfbe}}{\mathrm{V0}}\frac{\mathrm{EPSI}}{\mathrm{EPS}}\right)^{\frac{2 \cdot \mathrm{V0}}{V}}$$

$$n_{so} = N_c t_m \frac{V_e}{\mathrm{V0}} \exp\left(-\frac{\mathrm{DEF0}}{V_{th}}\right)$$

$$N_c = 3.0 \cdot 10^{25}\mathrm{m}^{-3}$$

$$V_e = \frac{2 \cdot \mathrm{V0} \cdot V_{tho}}{2 \cdot \mathrm{V0} - V_{th}}$$

$$t_m = \sqrt{\frac{\mathrm{EPS}}{2q \cdot \mathrm{GMIN}}}$$

$$V_{gte} = \frac{\mathrm{VMIN}}{2}\left[1 + \frac{V_{gt}}{\mathrm{VMIN}} + \sqrt{\mathrm{DELTA}^2 + \left(\frac{V_{gt}}{\mathrm{VMIN}} - 1\right)^2}\right]$$

$$V_{gt} = V_{gs} - V_T$$

$$V_{gfbe} = \frac{\mathrm{VMIN}}{2}\left[1 + \frac{V_{gfb}}{\mathrm{VMIN}} + \sqrt{\mathrm{DELTA}^2 + \left(\frac{V_{gfb}}{\mathrm{VMIN}} - 1\right)^2}\right]$$

$$V_{gfb} = V_{gs} - \mathrm{VFB}$$

$$I_{leakage} = I_{hl} + I_{\min}$$

$$I_{hl} = \mathrm{IOL}\left[\exp\left(\frac{V_{ds}}{\mathrm{VDSL}}\right) - 1\right]\exp\left(-\frac{V_{gs}}{\mathrm{VGSL}}\right)\exp\left[\frac{\mathrm{EL}}{q}\left(\frac{1}{V_{tho}} - \frac{1}{V_{th}}\right)\right]$$

$$I_{\min} = \mathrm{SIGMA0} \cdot V_{ds}$$

Temperature Dependence

$$V_{tho} = k_B \cdot \mathrm{TNOM}/q$$

$$V_{th} = k_B \cdot (\mathrm{TEMP})/q$$

$$V_{aat} = VAA\exp\left[\frac{\mathrm{EMU}}{q \cdot \mathrm{GAMMA}}\left(\frac{1}{V_{th}} - \frac{1}{V_{tho}}\right)\right]$$

$$V_T = \mathrm{VTO} + \mathrm{KVT}(\mathrm{TEMP} - \mathrm{TNOM})$$

$$\alpha_{sat} = \mathrm{ALPHASAT} + \mathrm{KASAT}(\mathrm{TEMP} - \mathrm{TNOM})$$

Capacitance

$$C_{gs} = C_f + \frac{2}{3}C_{gc}\left[1-\left(\frac{V_{sate}-V_{dse}}{2V_{sate}-V_{dse}}\right)^2\right]$$

$$C_{gd} = C_f + \frac{2}{3}C_{gc}\left[1-\left(\frac{V_{sate}}{2V_{sate}-V_{dse}}\right)^2\right]$$

$$C_f = 0.5 \cdot \mathrm{EPS} \cdot \mathrm{W}$$

$$C_{gc} = q\frac{dn_{sc}}{dV_{gc}}$$

$$n_{sc} = \frac{n_{sa}n_{sb}}{n_{sa}+n_{sb}}$$

$$n_{sa} = \frac{\mathrm{EPSI} \cdot V_{gte}}{q \cdot \mathrm{TOX}}$$

$$n_{sb} = n_{so}$$

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